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Completeness Assessment of Emergency System – Engineering Application in a Petrochemical Reservoir

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Abstract

A mature emergency system is the premise to ensure emergency planning to be performed perfectly. Aimed at the six emergency management goals, the challenge caused by risk potential and contribution caused by emergency competence formed by emergency system are calculated separately. The emergency system is viewed as mature when the emergency competence can encounter the risk potential effectively. The completeness assessment method is used in a petrochemical reservoir. The engineering application indicates that the evaluation results can reflect the general condition and the shortcomings of the emergency system. The advices given to the depot can help the safety manager to take some pointed measures to improve the emergency system.

Keywords: Completeness assessment; Emergency system; Engineering application

1. Introduction

All know that risk is permanent and safety is relative. But the influence caused by accident can be preventive and mitigated. The loss caused by the accident may be aggravated if the emergency system play disabled efficiency. Some references indicate that the accident loss can be reduced to 6% if the accident sites with the effective emergency system [1]. Hence the completeness of the emergency system affects much to the emergency rescue performance.

Towards to the assessment of emergency system, many researchers have done fruitful research [2-6]. But the emergency system is not isolated, its composition need to be consistent to the potential risk. Simple assessment of the emergency response system does not reflect the completeness of the emergency system.

The potential and emergency capability can not be compared for they reflected the different attributes of the subject. But one point should be emphasized is that both of them can affect the performance of emergency management. Towards the emergency management goals, potential risk will bring about the challenge and emergency system bring about the contribution. That is to say potential risk plays negative role and emergency system plays positive role to the achievement of emergency management goals. Hence according to the influence to emergency management goals, the potential risk and emergency capability forms by emergency system can be

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compared and the compare result is provided to justify the emergency system is whether mature or not. Authors have investigated a petrochemical reservoir and the index system characterized both potential risk and emergency system has been established. The application indicates that the evaluation results can reflect the general condition and the shortcomings of the emergency system. The advices given to the depot can help the safety manager to take some pointed measures to improve the emergency system.

2. Evaluation of emergency system completeness

Aiming at improving emergency management in China, six emergency management goals(EMGs) including initiate rapid response, control incident & prevent escalation, evacuate, escape & rescue, protect lives, protect environment and protect assets are established according to emergency management in some developed countries. Emergency capability and potential risk play positive and negative roles to fulfill EMGs separately. The qualitative evaluation of emergency system completeness is to judge whether the emergency capability formed by emergency system encounters the potential risk. The frame of emergency system completeness evaluation is shown in Fig.1.The framework includes a method of assessing the emergency management strategy.

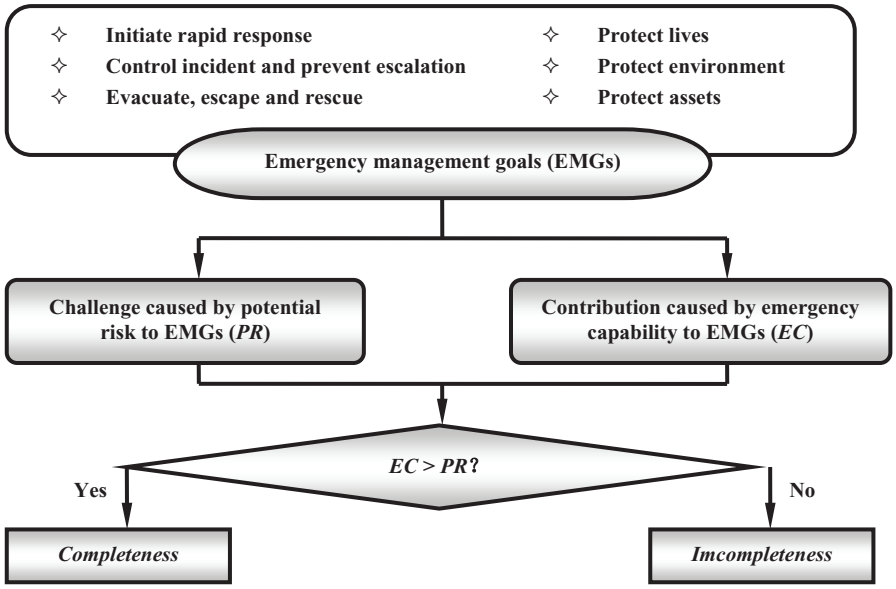

Fig.1. Frame diagram of emergency system completeness evaluation

From Fig.1, the aim is to provide a means of linking between potential risk and emergency capability to emergency management goals. Main phases and evaluation indicators of emergency system completeness evaluation are as follows[7]:

(1) Calculation of the challenge caused by potential risk (*PR*)

Factors that cause risk and play negative role in emergency management include inventory of materials in major hazard installations, complex of technology, population density, diversities of hazards, rate of escalation considering some worst credible scenarios and level of off-site risk.

(2) Calculation of the emergency capability (*EC*)

Emergency measurement of emergency management effectiveness through a set of key performance indicators ensures a repeatable, numerical measure of emergency capability. Factors which play positive role in emergency management contain emergency management philosophy, emergency management structure, emergency facilities, emergency management organization, emergency drilling and emergency planning. Details of the factors are demonstrated in Table 1. Further benefits can be obtained by grouping the performance indicator across a hierarchy of perspectives.

Table 1 Details of emergency capability

Factor	Content
Emergency management philosophy	Muster, shelter, evacuation and roll-call
	Emergency Alerting systems
	Relation with emergency services
	Emergency management team size and structure
	On site medical treatment capability
	On-site fire fighting capability
	Out of hours response from emergency management team
Emergency management structure	Selection of emergency managers
	Essential knowledge
	Emergency management competencies defined
	Defined requirements for training exercises
	Defined requirements for refresher training
	Competence assurance / assessment
Emergency facilities	Setting up
	Layout of emergency control centre
	Back-up emergency control centre
	Information management and display system in emergency control centre
	Information management and display system at-scene
	Range, redundancy and security of communications
Emergency management organization	Emergency procedures – content presentation and layout
	Call-out arrangements
	Emergency management organization resources
	Mandates for decision-making within emergency management team
	Relationships between emergency team members
	Contingency arrangements if key personnel unavailable
	Mandates for decision-making at on-scene command
	Mandates for muster-checkers
	Evidence of senior management commitment
Emergency drilling	Performance of emergency manager
	Performance of deputy emergency manager – if present
	Information management – during exercise
	Team performance
	Effectiveness of mandates
	Quality of scenario
	Operating beyond the procedural envelope
	Review and learning process
	Adequacy and effective use of resources
	Adequacy and effective use of facilities
Emergency planning	Emergency planning review and testing

(3) Evaluation of emergency system completeness

Potential risk calculated in step (1) and emergency capability calculated in step (2) are compared. The Emergency Management Competence is defined as follows:

$$\text{Completeness evaluation result for EMG} - j = \frac{EC \text{ score for EMG} - j}{PR \text{ score for EMG} - j} \quad (1)$$

where j is the number of the EMGs as 1, 2, 3, ⋯, 6.

Only when the evaluation result of emergency system capability is larger than the result of potential risk, the emergency system is mature; otherwise, the emergency system is immature.

3. Engineering application

3.1. Brief of the engineering case

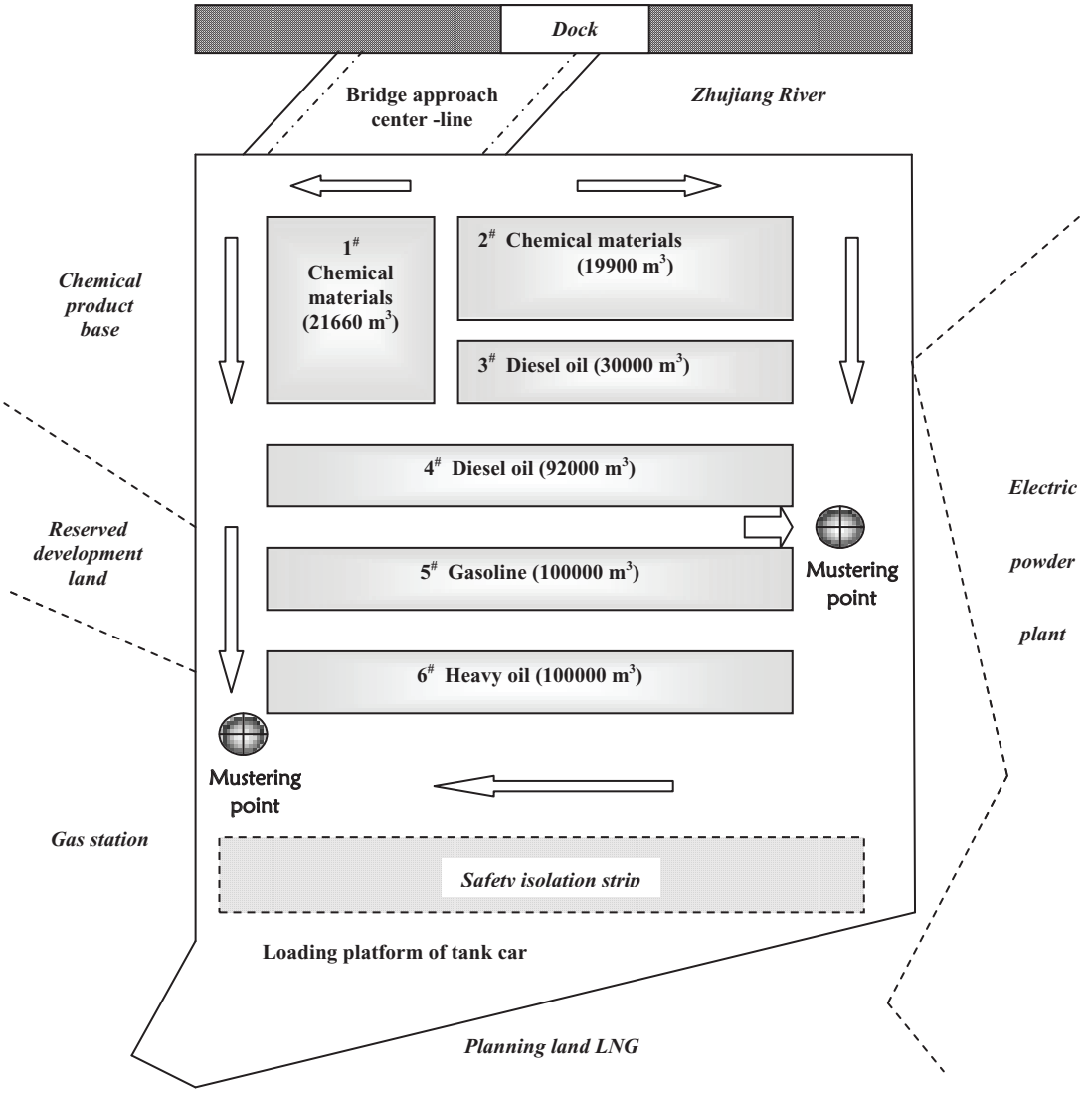

Fig.2. Lay-out of the tanks and evacuating routine in the depot

A petrochemical materials storage depot located at Zhujiang estuary is taken as an engineering application case. The total design storage capacity is about 36.3×10^4 m^3. Substances stored in the depot include petroleum, diesel oil, heavy oil and some other chemical materials. The position of depot, lay-out of the tanks and evacuating routine in the depot are shown in Fig.2.

The depot which has been put into operation for three years has the emergency drilling plan and schedule. There is a post emergency exercise in every three months and an integrated emergency drilling every year. Disadvantages are discovered after many emergency exercises in the past three years. The emergency planning is required to be revised in order to improve the action performance.

3.2. Completeness assessment of emergency system

(1) Potential risk assessment

According to the six potential risk elements analyzed in section 2, the potential risk of the depot and the information from questionnaires was summarized in Table 2.

Table 2 Information of potential risk in the case study

Potential risk index	Information in the case study	Score
Inventory of materials in major hazard installations	Many hazardous chemicals contain gasoline, carbinol, toluene, dimethylbenzene, acetone and paraxylene etc. are stored in the depot. According to National Standard of Major Hazard Installations Identification (GB18218-2000), the capacities of six substances are much higher than the critical capacity. The tanks or tank areas stored the six substances are viewed as major hazard installations.	86.67
Complex of technology	The capacity of the tank in the depot is too large, so the storing technology is very complicated.	73.33
Population density	The depot is located at developed area in Guangzhou. There are some other enterprises near it and the population around is not large.	40.00
Diversities of hazards	Chain control system is adapted in the depot. If one installation is abnormal, all the storage and delivery system are interlocked. The escalation of the abnormity is controlled.	70.00
Rate of escalation considering some worst credible scenarios	The lay-out of the depot meets the national standard and has passed the safety assessment.	71.67
Level of off-site risk	The depot is nearby Zhujiang River. Accident occurs in the depot maybe lead to serious environment effect. From Fig.5, there are a chemical product base, a gas station, an electric power plant and a LNG planning land bordering upon the depot. If accident occurs, it is likely to cause domino accident and aggravate the consequence.	63.33

(2) Emergency capability

According to the six emergency capability elements analyzed in Section 2, the emergency capability of the depot and the information from questionnaires was summarized in Table 3.

Table 3 Information of emergency management system

Index	Score
Emergency management philosophy	74.52
Emergency management structure	70.28
Emergency facilities	77.50
Emergency management organization	78.33
Emergency drilling	74.13
Emergency planning	76.67

(3) Assessment of emergency system completeness

Calculation results of the challenge to emergency management goals caused by potential risk and contribution to emergency management goals of emergency system capability are shown in Table 4.

Table 4 Evaluation results of emergency system completeness

Emergency management goals	Challenge caused by potential risk to EMG	Contribution of emergency capability to EMG	Completeness
Initiate rapid response	7.43	9.13	1.23
Control incident and prevent escalation	15.77	14.98	0.95
Evacuate, escape and rescue	13.60	15.19	1.12
Protect lives	7.09	12.00	1.69
Protect the environment	15.20	13.27	0.87
Protect assets	10.85	13.54	1.25
Emergency system completeness	69.96	78.12	1.17

From Table 4, the quantitative result of emergency system mature is 1.17 which is greater than 1.00. That is to say the emergency system established by the depot is capable of encountering the challenge caused by potential risk and it can provide the conditions for emergency planning to perform effectively.

4. Conclusions

The assessment method proposed in the paper explored a way to compare the potential risk and emergency competence by the establishment of emergency management goals. In this way, the shortcoming of single assessment to one aspect can be avoided. On the basis of the assessment results, the promotion advices of emergency system are provided combining the data investigation and drilling observation which can help the enterprises to complete the emergency system pertinently.

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